

# SCIENCE

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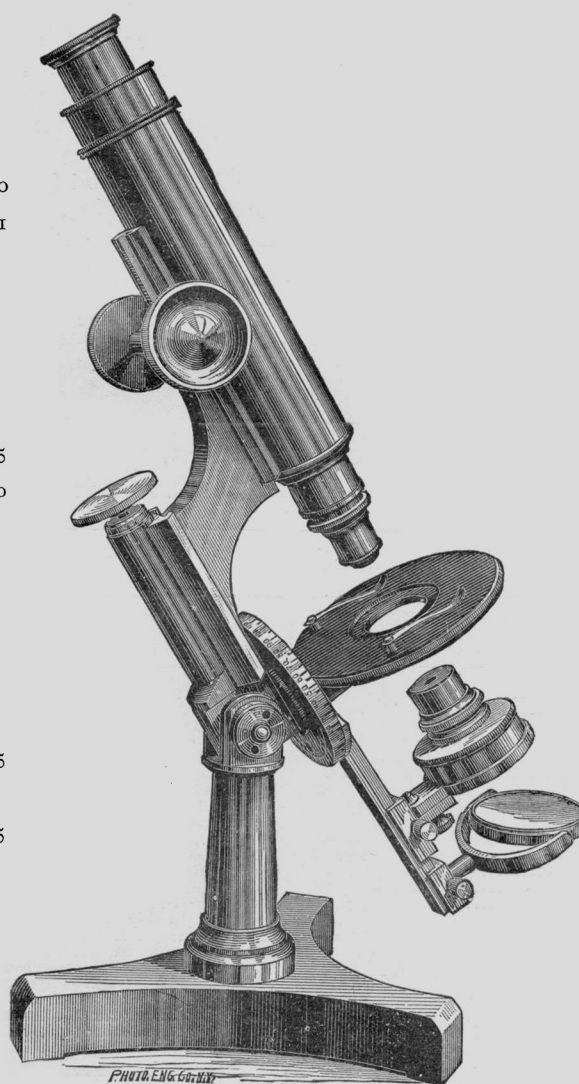
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# SCIENCE :

## A WEEKLY RECORD OF SCIENTIFIC PROGRESS.

JOHN MICHELS, Editor.

PUBLISHED AT

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SATURDAY, APRIL 2, 1881.

It has been well said, that the poorest day that passes over us is the conflux of two eternities: it is made up of currents that issue from the remotest past, and flow onward into the remotest future.

On the 27th of June, 1829, an event took place which was to have a marked influence on the intellectual development of the United States, for on that day James Smithson died at Genoa, Italy, bequeathing his whole fortune to the citizens of the United States, in trust, "*for the increase and diffusion of knowledge among men.*"

On the 6th of December, 1838, President Van Buren had the satisfaction of announcing to Congress that the claim of the United States to this legacy had been fully established, and that the money had been received by the Government.

The question then arose, what plan could be devised to carry out the intentions of the testator. In other words, how could "the increase and diffusion of knowledge among men" be best accomplished.

One of the first proposals for utilizing the Smithsonian fund was a scheme of founding a university of high grade, to "teach Latin, Greek, Hebrew, Oriental languages, and other branches of learning, including rhetoric, poetry, laws of nations, &c." Fortunately, such counsel did not prevail, and after nearly eight years of debate, and even a proposal to return the money to England being voted on, a bill was passed by Congress organizing the Smithsonian Institution on its present basis.

Such, briefly stated, was the origin of the Smithsonian Institution, and in memory of its founder the present Secretary, Professor Spencer F. Baird, directed Mr. William J. Rhees to compile a biography\* of James Smithson, this work being one of the most recent publications of the Institution.

The general scope of this work is good, and it must be admitted that some account of the establishment of this Institution was called for. We must, however, express our regret that such an elaborate description

of Smithson's aristocratic connections was presented, especially as the history would have been equally complete without this superfluous addition. The connection of the "proud" Dukes of Northumberland and Somerset with Smithson was hardly of a nature to be recorded in a form which should constantly bring the facts before the present generation and posterity.

The circumstances of Smithson's birth cannot be ignored, but there is no reason why they should be paraded before the public; we therefore would have dispensed with the portrait of the first Duke of Northumberland in this volume, and relegated the history of his life and death to the highest shelf in the Smithsonian Library.

Stript of such surroundings, the memory of Smithson must ever be dear to the people of this country. He was a man thoroughly imbued with the spirit of true science, and an active and industrious laborer in one of the most interesting and important branches of research—"mineral chemistry." His happiest hours were spent in the laboratory, where he carried on a series of experiments, which were recorded in the transactions of the Royal Society of London and other scientific journals of the day. Such being the direction of Smithson's scientific pursuits, we trust that the advancement of the physical sciences may claim the attention of the officers of this institution, and that they may be more duly represented in future reports.

Since the death of Smithson, Chemistry has attained a higher rank among the exact sciences. New methods and instruments of analysis have been introduced, while other branches of science have advanced at an equal ratio. New means "for the increase and diffusion of knowledge among men," have come to light, and among these the production of improved scientific manuals, and the increased number and excellence of scientific periodicals and journals, may be mentioned as having largely contributed to such results. Science at the present day is no longer monopolized by a select few, but is claimed as the common heritage of the thousands who have the intelligence to appreciate its value in developing the highest faculties of man.

Thomas Carlyle considered that "to know the divine laws and harmonies of this Universe must always be the highest glory of a man, and not to know them the highest disgrace for a man." This Journal represents one of the latest attempts to place at the disposal of all interested in scientific pursuits and human progress, a weekly journal worthy of the subject discussed. We are glad to find that our efforts have been appreciated, and the constant receipt of letters of welcome, co-operation and aid, increases our hopes for the future. Among our latest subscribers, we find three residing in Japan, one in Lucknow, India, another in New Zealand, and the directors of the Royal observatories of Brussels, Lisbon, and Rome have added their names. If "SCIENCE" is thus in demand in foreign countries, we trust to find our home subscription list rapidly increase, which will enable us to enlarge and improve the journal in various ways, thus adding to its usefulness.

Lord Brougham observed, that to instruct the people in the rudiments of philosophy, and to obtain

\* James Smithson and his bequest, by William J. Rhees, published by the Smithsonian Institution, Washington, 1880.

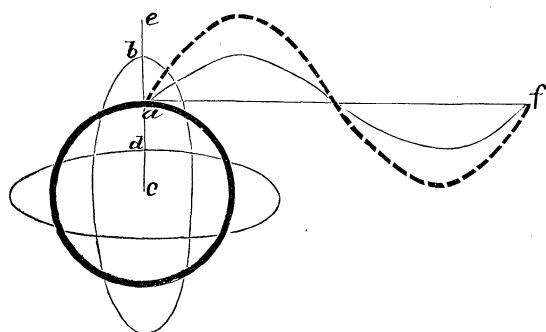
for the great body of our fellow creatures that high improvement, which both their understanding and their morals fit them to receive, is an object sufficiently brilliant to allure the noblest ambition. Without claiming such lofty aspirations, the promoters of "SCIENCE" yet look forward to the time when their efforts to establish this journal may be recognized as at least a step in that direction.

### ON THE AMPLITUDE OF VIBRATION OF ATOMS.

PROF. A. E. DOLBEAR, TUFTS COLLEGE, MASS.

There is now sufficient evidence for the belief that the kinetic energy of atoms and molecules consists of two parts, one of which is the energy of translation or free path, the other of a change of form due to vibrations of the parts of the atom or molecule toward or away from its centre of mass. The pressure of a gas is immediately due to the former while the temperature of the gas depends solely upon the latter. These two forms of energy must indeed be equal to each other in a gas under uniform conditions; for if one exceeded the other in energy when there is as free a chance for exchange as among the atoms of a gas, there would result an increase of pressure on the one hand, or an increase of temperature on the other. Now the kinetic energy of a mass  $m$  and velocity  $v$  is expressed by  $\frac{mv^2}{2}$  and applies as well to an atom as to a musket bullet, and if we take the mass of the hydrogen atom as unity and employ the calculated velocity of hydrogen atoms at  $0^\circ$  Cent. and 760 mm. pressure, namely 1860 metres per second, the energy will be  $\frac{(1860)^2}{2}$ .

We know also how many times the hydrogen atom vibrates per second, by dividing the velocity of light per second by some chosen wave length  $\lambda$ ; so that  $n = \frac{v}{\lambda}$ . If attention be now directed to the vibrating atom possessing the same energy as in the free path movement, it will be seen that its *velocity of vibration* must also be equal to 1860 metres per second. But vibratory velocity is the product of a number  $n$  into an amplitude  $a$ , so that  $v = na = 1860$ .



Adopting the vortex-ring theory of matter, the dark ring represents the atom which, when executing its simplest vibration assumes consecutively the conjugate ellipses and any point  $a$  in the circumference will move over the line  $b$ , the latter distance consti-

tuting the amplitude of the vibration. The limits to this movement must clearly be between  $b$  and  $d = 0$  when there is no vibration, the absolute zero of the atom and  $c$  and  $e$  which can never exceed  $\frac{1}{2} \pi r$  and indeed must always be less than that value; for when half the major axis of the ellipse is equal to that it has become a straight line. As atomic vibrations result in undulations in ether it is evident that amplitude  $b$  and  $d$  will give an undulation  $af$  shown in continuous line, while maximum amplitude  $c$  and  $e$  would give same wave length shown in broken line. The greater the actual thickness of the ring the less must be the possible maximum amplitude.

The amplitude then becomes comparable with the diameter of the atom, and in this discussion the assumed diameter is the one given by Maxwell, namely .0000005 mm.

The numerical value of  $\frac{1}{2} \pi r$  for such a diameter is .0000004 mm. which represents the theoretical maximum amplitude for a hydrogen atom.

If any hydrogen wave length be taken, say  $C = .0006562$  mm. the ratio of wave length to maximum amplitude is  $\frac{.0006562}{.0000004} = 1640$ , that is wave length is

1640 times such amplitude. But hydrogen  $C$  is not the fundamental vibration, but according to Stoney is the 20th harmonic of a fundamental having a wave length of .013127714 mm. and  $\frac{.013127714}{.0000004} = 32819$ . That is, it is 32819 times greater than the amplitude.

Now, Sir William Thomson, in his calculations on the amount of energy in the ether, assumed that the amplitude should not exceed one-hundredth of the wave length, but that value is evidently very many times too large. An undulation with the wave length of this fundamental for hydrogen is nearly twenty times longer than the longest one that can be seen; and as the sensation of light depends upon wave length and not upon amplitude, or what the energy of the ray, it follows that Dr. Drapers' deductions concerning the temperature of bodies beginning to be luminous will not necessarily apply to gases, for when extra energy is imparted to the atoms of a gas it is the amplitude of their vibrations that is affected, and if the impacts are sufficiently frequent some of the harmonic vibrations may appear continuously, but they will not thereby necessarily indicate a higher temperature, but show that the energy is distributed in two or more periods, some of which have resulting undulations which may be seen; but this will depend upon the density of the gas. Suppose a body capable of vibrating  $a$  times per second for its fundamental, be struck  $b$  times per second; then will the rate of vibration be interfered with  $\frac{a}{b}$  times. If  $b$  be less

than  $a$ , then will the fundamental vibration have more than its required interval between impacts, and a certain number of these fundamental vibrations will be made per second. If  $b$  be equal to  $a$ , then, after the first impact,  $a$  will vibrate in its own period with increasing amplitude, without interference. If  $b$  be greater than  $a$  then will the impacts interfere in all phases of the vibrations, the fundamental will be destroyed, and only some harmonics and irregular vibrations will be possible; but the number of impacts

per second depends upon the density, and in solids and liquids this secures the destruction of the fundamental vibrations as the energy of vibration is increased, at the same time developing the multitude of irregular ones shown in the spectrum; while in a gas the number of impacts per second is many times less than the regular rate of vibration, and this secures the time for either fundamental or harmonics, and the consequent spectra. The number of vibrations  $n$  the hydrogen atom makes when the wave length is .0131277 mm. will be  $n = \frac{v}{\lambda} = \frac{3 \times 10^{11}}{.131277} = 2286 \times 10^{10}$ .

Let  $v'$  represent the velocity in free path motion of the atom at  $0^\circ$  Cent. and 760 mm. pressure = 1860000 mm. Their amplitude  $a$  will equal  $\frac{v'}{n} = \frac{1860000}{2286 \times 10^{10}} = 8134 \times 10^{-11}$  m. Comparing this with the diameter of the atom  $\frac{8134 \times 10^{-8}}{5 \times 10^{-7}} = .162$ . That is the amplitude is equal to .162, the diameter of the atom at  $0^\circ$ .

Assuming a temperature higher than this, say  $273^\circ$  Cent., then the energy of the atom in its free path motion compared with that it has at  $0^\circ$  will be as  $\sqrt{2}$ : 1 and  $1 : \sqrt{2} :: 1860 : 2630$  m. per second, and as before amplitude  $a$  will equal  $\frac{v'}{n} = \frac{2630000}{2286 \times 10^{10}} = 115 \times 10^{-7}$ . This compared with the diameter of the atom gives  $\frac{115 \times 10^{-7}}{5 \times 10^{-7}} = .23$ . That is, the amplitude is equal to .23 the diameter at  $273^\circ$  Cent., a difference of .068 for  $273^\circ$ .

With same data the maximum temperature of the hydrogen atom may be calculated for as

$$(.162)^2 : (.7854)^2 :: 273^\circ : 6419^\circ$$

which would be the highest temperature the atom could have if it could have such an amplitude, and this will be reduced as the thickness of the ring increases. Any additional energy the atom would receive could not possibly heat it but would be expended either in rotating it or in giving to it a free path motion. In like manner the amplitude for a single degree is found to be .0098 diameter, or very nearly one-hundredth the diameter.

For other atoms than hydrogen when they have the same energy their amplitude must vary inversely as their mass, so that for oxygen the amplitude at  $273^\circ$

would be  $\frac{.162}{16} = .01$  its diameter, and its maximum temperature will be  $6419 \times 16 = 102704^\circ$  Cent., a number altogether too high for the same reason as was given for hydrogen, namely it assumes that the ring has no thickness.

If these computations have any value they may be applied to the solution of the temperature of the sun.

The elements having the greatest density must have the highest maximum temperature. In the sun twenty-five elements have been determined spectroscopically and the average density of these twenty-five is 63. Now on the hypothesis that these elements exist in equal quantities in the sun, which is not very probable, the maximum temperature of that body would be about  $400000^\circ$  Cent.

As at absolute zero each atom is quite independent

of every other atom, that is, matter has not a molecular structure, so, at certain high temperatures that differ for different substances, all molecular groupings must be broken up and the atoms are quite dissociated from each other, and this dissociation must occur before the maximum temperature is reached; it would appear that whenever at the sun the temperature approached its maximum, then the elements would be elementary, uncombined, and if compounds are observed or appear probable from phenomena witnessed, that will be the best evidence that the temperature is decidedly lower than the above figure. For hydrogen the dissociation temperature is only about  $700^\circ$  Cent. which is only about one-ninth its maximum.

#### MARSH'S ODONTORNITHES.\*

Were there no other proofs of his zeal and success in extending the bounds of knowledge, the writer of this magnificent monograph would be famous as—for ten years at least,—the sole discoverer, describer and possessor of the remains of Extinct Toothed Birds of North America.

It may befall almost any diligent explorer to find the remains of some species previously unknown, but few have had—or so well-deserved—the privilege of presenting to the world a new series of facts embodying a new idea, at once easily appreciated by the many, and serving the few as material for profound consideration. That a bird with teeth is, most literally, a *rara avis*, may be conceded without extensive acquaintance with either Latin or Ornithology; on the other hand, it is probable that naturalists have not yet wholly realized the import of this fulfillment of a prediction which might have been made legitimately—though we are not certain that it ever was—at any time during the last twenty years.

Aside from the Appendix, the present volume embraces detailed descriptions of the bones and teeth of *Hesperornis* and *Ichthyornis*; a general description of the “Restoration” of each genus; and a “Conclusion” embracing the author's views upon the taxonomic relations, and probable evolution of these two forms, together with *Archaeopteryx*.

The following are the principal characteristics of the two American genera, chiefly as recapitulated upon p. 187. In *Hesperornis*, the articular ends of the vertebral centra are saddle-shaped, as in recent birds; in *Ichthyornis* they are biconcave, as in many fishes: *Ichthyornis* has a prominent sternal keel for the attachment of the muscles of the well-developed wings; in *Hesperornis*, the sternum is without a keel, and each wing is represented by only a rudimentary humerus: the wing-bones of *Ichthyornis* have tubercles evidently for the attachment of feathers; no signs of feathers have been observed with *Hesperornis*, but they doubtless were present in life: in both genera, the caudal vertebrae are few, so that the bony tail is short as in recent birds: in both, the mandibular rami seem to have remained permanently ununited by bone: in both, as indicated by casts of the cranial cavity, the prosencephalon was narrower than in recent birds of

\*Odontornithes: A Monograph on the Extinct Toothed Birds of North America; with thirty-four plates, and forty woodcuts. With an Appendix giving a Synopsis of American Cretaceous Birds. By Othniel Charles Marsh, Professor of Paleontology in Yale College. Memoirs of the Peabody Museum of Yale College, vol. 1; pp. 201. This memoir will also form vol. vii, Survey of the 40th parallel.

similar size, a point of much interest, in view of what has been noted by Prof. Marsh with regard to the brains of extinct Mammals: finally, both forms had *well-developed teeth in both jaws*, but those of *Hesperornis* were implanted in a continuous groove, while those of *Ichthyornis* had separate sockets.

Prof. Marsh calls attention to the peculiar combination, in *Ichthyornis*, of a low feature—the biconcavity of the vertebræ—with a comparatively high method of implantation of the teeth, and adds: "Better examples than these could hardly be found to illustrate one fact brought out by modern science, that an animal may attain great development in one set of characters, and at the same time retain other low features of the ancestral type. This is a fundamental principle of Evolution."

Naturally, the teeth are described and figured with especial fullness and accuracy. Their general features are distinctly reptilian, as would have been inferred. Curiously enough, in neither genus does the dental series reach the tip of either jaw, and, in *Hesperornis*, "the extremity of the premaxillary bone, back to the nasal openings, has its surface pitted with irregular vascular foramina, indicating, apparently, that it was once covered with a horny bill, as in modern birds." P. 8.

With the exception of *Archæopteryx*, all the known odontornithic remains are in the Museum of Yale College, but their discoverer is clearly of opinion that more are to be found:

"These three ancient birds, so widely different from each other, and from all modern birds, prove beyond question the marvellous diversity of the avian type in mesozoic time, and also give promise of a rich reward to the explorer who successfully works out the life-history of allied forms, recorded in ages more remote." P. 189.

He even ventures to define the leading features of the, at present, hypothetical progenitor of the entire group of birds: "In the generalized form to which we must look back for the ancestral type of the class of birds, we should therefore expect to find the following characters: Teeth in grooves; vertebræ biconcave; metacarpal and carpal bones free; sternum without a keel; sacrum composed of two vertebræ; bones of the pelvis separate; tail longer than the body; metatarsal and tarsal bones free; four or more toes, directed forward; feathers rudimentary or imperfect; quadrate bone free." P. 188.

As compared with this generalized form, our modern birds, while endowed with intense functional activity, and in some structural features—especially as to their true dermal appendages—a most highly specialized group, are nevertheless, odontologically considered, degenerated and retrograded creatures.

The general bearing of the facts given in this memoir upon the question of evolution has been well stated by Prof. Marsh upon a previous occasion.

"*Compsognathus* and *Archæopteryx* of the Old World, and *Ichthyornis* and *Hesperornis* of the New, are the stepping-stones by which the evolutionist of to-day leads the doubting brother across the shallow remnant of the gulf, once thought to be impassable."

So far we have had to deal either with facts, or with hypotheses based upon those facts and warranted by the prevailing opinions respecting evolution in gen-

eral. There remains to be considered the bearing of these same facts upon the zoological relations of the toothed birds to the rest of the class. Here there is room for very wide disagreement, and the only point, perhaps, upon which all seem to be in accord, is that the Birds, as a whole, form a *class* of vertebrates, whether or not they should be combined with the reptiles as a super-class or sub-branch—Sauropsida.

The advantages of employing a single technical term like *odontornithes* in place of *aves dentatæ* or *toothed birds* will be generally conceded, and the use of the term as a convenient designation of certain forms need not imply more than is implied by the words *swimmer*, *flier*, *apoda*, etc. The real question is, do the toothed birds constitute a natural subdivision of the class Aves, comparable for instance with the Marsupials among the mammalia? If not do they constitute an order or a family, or, finally, are they—or some of them—simply representatives of two or more natural groups, differing from the other members of those groups, and associated together, by the possession of teeth?

In a natural classification, we expect to find animals collocated either because they agree in many particulars, or because they have in common one or more features of primary importance. For example notwithstanding their immense variety in size, form, habit, existing birds present a remarkable uniformity of structure, even in some apparently insignificant details. On the other hand, although *Amphioxus* differs from all other Vertebrates in so many respects that nearly all generalizations as to the branch must be accompanied by a qualification, yet it shares with the rest a developmental feature and a general arrangement of organs which keep it within the branch and separate it from all other animals, excepting perhaps the Ascidians.

Prof. Marsh regards *Archæopteryx*, *Hesperornis*, and *Ichthyornis*, as the representatives of as many orders of the subclass Odontornithes, to which he applies the names Saururæ, Odontolcæ, and Odontormæ. The first of these names had been employed already by Hæckel and Huxley, who, however, had made the Saururæ, Ratitæ (ostrich, etc.) and Carinatæ, (all other birds) subclasses of the class Aves. Marsh does not say what he thinks should be done with the Ratitæ, but if he is correct in his opinion (p. 3.) that "*Hesperornis* and *Ichthyornis* differed more from each other than do any two recent birds," it would seem to follow that the Ratitæ can no longer constitute a subclass of the recent and toothless birds.

In the condensed statement of the characters of the orders (p. 187) it is shown that we are unacquainted with the mode of implantation of the teeth of *Archæopteryx*, with the form of its vertebræ and sternum, and with the extent of union of the mandibular rami. The characters enumerated are the *presence of teeth, small wings, separate metacarpalia and a bony tail longer than the body*.

It will be seen that, excepting the teeth, any generalization respecting the Odontornithes as a whole, must be accompanied by a qualification respecting one or two of the orders. Prof. Marsh points out that the three groups present unequal degrees of affinity. But even if we exclude *Archæopteryx*, the only characters which are at the same time common to the

Odontolcæ, and Odontotormæ and absent from recent birds, are the narrowness of the proencephalon, the persistent separation of the mandibular rami and the presence of teeth.

That the presence of teeth has been regarded by Prof. Marsh as the principal—if not the only essential—characteristic of the Odontornithes, is indicated by the following passages from the present work, or from previous papers.



TOOTH OF *Hesperornis regalis*, SHOWING GERM OF YOUNG TOOTH.

"Both of these types possessed teeth, a character hitherto unknown in the class of birds, and hence they have been placed by the writer in a separate sub-class, the Odontornithes." P. 3.

"That *Archæopteryx* belongs to the Odontornithes, the writer fully satisfied himself by a personal examination of the well-known specimen in the British Museum. The teeth seen on the same slab with this specimen agree so closely with the teeth of *Hesperornis*, that the writer identified them at once as those of birds and not fishes." P. 186.

In speaking (p. 191) of the "bird remains found in the Green-Sand deposits of New Jersey," our author says; "as neither jaws nor teeth have yet been detected, it is at present impossible to say whether the Eastern species belong to the Odontornithes."

Before the discovery of the teeth, he had characterized the *Hesperornis regalis* as a "gigantic diver related to the Colymbidæ." His preliminary description of the same bird had been to the same effect, with the addition "that it differs from the Colymbidæ so widely in the structure of the pelvis and posterior limbs as to demand a place in at least a separate family."

In the present publication, however, our author is of opinion that "the struthious characters seen in *Hesperornis* should probably be regarded as evidence of real affinity, and in this case *Hesperornis* would be essentially a gigantic swimming ostrich." P. 114.

That Prof. Marsh's opinion as to the taxonomic value of the teeth is shared by zoologists generally, is shown—at least negatively—by the absence of dissent from his own views and from those of such reviewers as Newton and Woodward. The former speaks of the "teeth, whence the *Ichthyornis* has been made the type of a distinct sub-class." The latter, writing of the same genus, says: "The possession of teeth and biconcave vertebræ, although the rest of the skeleton is entirely avian in type, obviously implies that these remains cannot be placed in the present group of birds, and hence a new sub-class, Odontornithes is proposed for them." In the added note, respecting *Hesperornis*, Woodward does not state whether he was then aware that the vertebræ of that

genus lacked the biconcave character. Hence it is not certain whether he would regard it as an odontornith by reason of the teeth alone.

Prof. Huxley does not distinctly mention the degree of separation of the toothed birds from the rest, but he says that the *Hesperornis regalis* "in a great many respects is astonishingly like an existing diver or grebe, so like it indeed, that had this skeleton been found in a museum, I suppose—if the head had not been known—it would have been placed in the same general group as the divers and grebes of the present day."

So far as I am aware, no objection to the erection of a sub-class upon a purely dental basis, has been offered, even upon the part of some who have not usually been slow in criticising our author's conclusions.

Yet Prof. Marsh himself appears to be by no means settled in his conviction as to the taxonomic relations of the forms in question, since his "Conclusion" contains the following qualified expression of opinion: "For the present, at least, it seems advisable to regard the Odontornithes as a sub-class, and to separate them into three orders."

The above intimation of a willingness to review this part of the subject removes the hesitation which one naturally feels in differing from the highest—and, in one sense, the only—odontornithological authority, and I therefore venture to offer certain considerations which seem to have been overlooked hitherto.

1. Are the other characters of the toothed birds such as to warrant their separation as a sub-class? In other words, can we conceive of *edentulous* Odontornithes as we have Vertebrates without vertebræ, and Edentates provided with teeth?

2. Why should the presence of teeth in certain birds be accounted of more taxonomic significance than the absence of the same organs in the members of other classes? The truly edentulous edentates are held to form merely families or sub-orders; the (toothless) turtles are commonly regarded as an order of reptiles; and Prof. Marsh himself has established the sub-order Pteranodontia, the "distinctive feature of which as compared with the other Pterosauria, is the absence of teeth."

3. If birds with teeth had been known to us at all times, or in the recent state, or in great number and diversity, is it probable that, the entire group having the rank of a class, we should have been led to form two primary groups, the Odontornithes and the Anodontornithes.

4. How would the question appear in case unmistakable evidences of teeth are found in the embryos of recent birds? That such signs will be sometime discovered can hardly be doubted, especially when the embryology of the ostrich is as well known as that of the common fowl. Some are even now of opinion that such structures have been seen. So cautious a compendium as Rolleston's *Forms of Animal Life*, says: "dental papillæ, with caps of dentine, have been observed in the embryos of Psittacidæ." Since, however, Prof. Marsh holds (p. 13) that the "vascular papillæ seen by St. Hilaire and others were apparently portions of the horny beak," we may consider the point unsettled.

5. May it not be that, in our natural surprise at the



HESPERORNIS REGALIS, MARSH.



unexpected presence of teeth in connection with an otherwise bird-like structure, we have overestimated the true taxonomic significance of the facts, and lost sight, for the moment, of our customs in other groups? May it not be, indeed, that we have been unconsciously affected by the phenomenal nature of most of Prof. Marsh's palæontological discoveries, and that we have not only been unduly impressed by the facts, but also influenced in some degree by the general admiration for the discoverer's achievements, so as to refrain from questioning his conclusions? Yet, as has been shown already, our author has kept his own mind open upon this very point, and it is to be hoped that he may have the pleasure and the honor of discovering other forms of *Aves dentatæ*, affiliated in other respects to the several groups of existing birds, and held together only by their teeth.

Hereafter such problems as are involved in this memoir will be discussed more advantageously in the light of the considerations respecting the Evolution and Classification of Vertebrates which have been presented recently by Prof. Huxley.

So admirable is the present work as a whole that one shrinks from any criticism of details. Upon the following points, however, some improvement could, perhaps, have been made:

While insisting upon the lack of bony union of the ends of the mandibular rami in the American *Odontornithes*, our author makes contradictory statements in regard to the tissue by which they were joined during life. On pages 11 and 179 it is said to have been *ligament*; on page 123, and in the explanation of plate 1, *cartilage* is specified, while on page 112 the union is said to have been "as in serpents." Judging from the appearance of the surface shown in plate 1, fig. 4, the union was ligamentous rather than cartilaginous, but there may have been a mingling of the two kinds of tissue.

The date of the discovery of *Hesperornis* is given as November, 1870, on page 2, but as December on page 195.

It would have greatly facilitated references if there had been given in this volume a complete Bibliography of *Odontornithology*, together with a statement of the dates of discovery of the various forms, and the dates of their assignment to more comprehensive groups than species and genera. The synonymy as given under the species named in the Appendix does not quite meet this want.

In view of the aid which evolution has received from embryology, it would seem that even a special palæontological memoir like the present might have contained some expression of the author's expectation that light may sometime be thrown upon the problems involved by the careful scrutiny of the development of certain recent birds, notably the *Struthionidæ*.

B. G. W.

REPORT SUBMITTED TO THE ACADEMY OF MEDICINE ON THE SUBSTITUTION OF MARGARINE FOR BUTTER AND LARD IN THE PUBLIC ASYLUMS OF THE DEPARTMENT OF THE SEINE.—M. Riche finds that pure butter yields a quantity of fatty acids insoluble in water ranging from 86.5 to 88 per cent of the weight of the pure fatty matter, whilst in all the other fats and animal oils, and in almost all vegetable oils, there is from 95.20 to 95.80 per cent of insoluble fatty matter.

## ON THE SOUTHERN STARS AND OTHER CELESTIAL OBJECTS.

BY J. H. POPE, NEW ZEALAND.

This paper embodies the results of observations made during the last eight years. While most of the work is original, yet, when the object described is important, and an account of my observations could not be satisfactorily given without reference to the work done by previous observers, their facts and opinions have been quoted. An apology is scarcely needed for giving a short *résumé* of the facts known about the great star *Alpha Centauri*; accordingly, a very brief history of this remarkable object, from Lacaille's time (1750) to the present has been given.

The instruments used were an 8½ inch reflector, by Browning, and a 4¼ inch equatorial of superior quality. The measures of angles and distances have been obtained by the methods described in my paper in last year's "Transactions."\* The angles of position will, I have little doubt, be found to be good, but the atmosphere has not been steady enough of late to admit of the best use being made of oblique transits. I have, however, little doubt that such measures of distances as are given will be found to be very satisfactory approximations to the truth. For the spectroscopic work recorded in this paper I have used an admirable little star-spectroscope, by Browning. This instrument has enabled me to determine, quite satisfactorily, the class to which the stars examined belong, and, in many instances, to say that the spectrum lines of certain elements are probably present. As, however, the means at my disposal did not permit me to make accurate *measures* of the positions of lines, my work in this department should be looked upon as the results, so to speak, of a "flying survey," useful perhaps, in its way, but to be superseded when more thorough and accurate determinations can be obtained.

It should be stated, however, that, while depending on eye estimation alone, it would be very unsafe for an observer to say, that a conspicuous line, for instance, in the greenish blue of the spectrum of a certain star was certainly the F hydrogen line; yet it is unlikely that a practiced eye, one trained to recognize the position of certain lines in spectra that have been already measured, could be mistaken, in any large proportion of cases, in picking out, say, the principal Fraunhofer lines in a stellar spectrum. On the whole, it seems to me that such determinations as are given in this paper are not without a real value, if carefully made. Many years must elapse before the lines in the spectra of the southern stars can be accurately measured by methods like those employed by Dr. Huggins. In the meantime such results as those here given are all that are available. These serve to give us a certain amount of information that can be thoroughly relied on; they enable us to state, further, that the existence of certain physical conditions, and the presence of certain elementary substances in certain stars, are highly probable; and, possibly, they are calculated to create or stimulate in us a desire to learn more certainly and fully the constitution and physical habits of the stars.

The objects are treated of in the order of their Right Ascension, and the places of the stars when given, are taken from the "First Melbourne Catalogue," epoch, 1870.

The first star on the list is *Achernar* or *α Eridani*. This fine first magnitude star is very nearly pure white, without any discernable tint, except possibly a slight shade of blue. This star belongs to Padre Secchi's first class of stars, the type of which is the giant sun *Sirius*. In the case of typical stars of this class, the spectrum is

\* Trans. N. Z. Inst., Vol. XI., Art. X.

remarkable for the great breadth and distinctness of the hydrogen lines. Indeed these stars are for convenience often called "the hydrogen stars." All of them are white or bluish-white. In *Achernar* the hydrogen lines are not nearly so strongly marked as they are in some others of the class. Indeed the star by no means nearly approaches the type, and is probably to be considered as holding a position between such stars as *Sirius* and stars of the second class, like *Procyon*, though much nearer to the former than to the latter.

*π Eridani*.—This beautiful little double-star is just visible with the naked eye in fine weather. It is about one degree from *Achernar*, north following. The two components are of the same orange color, and of very nearly equal magnitudes 7 and 7. When Sir John Herschel measured this star (anno 1835.0), he found the angle of position with the meridian to be  $122.3^\circ$ . Powell, in 1863, found the angle to be  $73.9^\circ$ . Last week (say anno 1879.75) the angle was  $58.8^\circ$ . The distances for the same dates are  $3.65''$ ,  $4.88''$ , and  $5.3''$ . This interesting double is, therefore, very probably a binary star of comparatively short period.

*θ Eridani*.—R. A. 2hrs. 53min. 19.9 secs. Decl.  $40^\circ 49' 35''$  S. In the Melbourne Catalogue, the magnitudes 5.2 and 6.2 are assigned to the components of this fine double-star. There is most certainly serious error here. The star is plainly, taken as a whole, a large fourth, or a small third-magnitude star. Probably magnitude 3.9 for the larger star, and 5.9 for the smaller one, would not be far from the truth. The color of the larger star is yellowish-white, with a faint green tinge; the smaller is a light shade of indigo blue. Sir John Herschel's angle of position and distance, in the year 1835.75, were  $81.5^\circ$  and  $8.68''$ . The angle at the epoch 1879.75 is  $85.4^\circ$ . I have not been able to get a thoroughly satisfactory distance, but it is now somewhat over  $10''$ . Time and accumulated observations will, of course, show either that the change in the angle and the distance of the two stars of this double is owing to the proper motion of one, or both, of the components, or that *θ Eridani* is a binary system. The latter alternative appears to me to be by far the more probable.

*232 Reticuli* of the Melbourne Catalogue is a fine star of a magnificent scarlet color. It is of magnitude  $6\frac{1}{2}$ . There is a distant companion white star of the eleventh magnitude. The R. A. of *232 Reticuli*, is 4hrs. 35min. 15.15 sec., and the declination  $62^\circ 20' 0.63''$  S. The spectrum of this star is very remarkable. It belongs to Secchi's fourth class. The typical star of this division is small—invisible, in fact, to the naked eye; it is variable both in light and color; it is a very distinct red, ruby, crimson, or scarlet; and its spectrum consists of bands of light, sometimes containing faint bright lines with dark spaces between the bright bands. *232 Reticuli*, though so small, gives a fine spectrum when the spectroscope is used with the reflector, because the light is not spread out over the whole length of the spectrum, but is concentrated in certain parts of it. Thus the red part of the spectrum is very bright, but the place of the orange is occupied by a very thick black "bar." The yellow, again, is pretty bright, and so is part of the green, but towards the violet end of the spectrum the light is very faint, and the colors are quite cut out for large spaces by intervals of almost complete darkness. I failed to notice here what is said to be characteristic of this class of stars—a gradual diminishing blackness of the bars in the direction of the violet end of the spectrum; nor could I distinguish any bright lines in any part of the spectrum. The study and observation of stars of this class is none the less interesting to us, because in the present state of our knowledge their spectra are unintelligible, for it is generally felt by those who have been in the habit of observing them, that there is a great secret of nature waiting to be discovered in connection with them. Their being for the most part so very variable both in light and color, the strongly-

pronounced red color of all of them, and their strange and beautiful spectra, all point to the conclusion, that the man who succeeds in "reading the riddle" of the nature and constitution of the red variable stars, will have made a very important contribution to our knowledge of the process by which suns and systems are evolved out of the primordial nebula, or whatever the substance may be, from which such systems are formed, and to which, perchance, when their mission is fulfilled, they again return. In the meantime these red stars seem to set anything, even like rational conjecture, at defiance.

*α Argus (Canopus)*.—This great star, the only rival of *Sirius*, is a hydrogen, or first-class star. In its spectrum, the F and C hydrogen lines, and that near G, are broad and distinct, though less so than in the spectrum of *Sirius*. There are a great many very fine lines in the spectrum of *Canopus*, but these are not generally visible. It is only when the atmosphere is very steady and clear that they can be plainly seen. A fine line, however, or rather a small group of lines, in all probability that called *b*, and due to the presence of magnesium in the photosphere of the star, can generally be made out in moderately fine weather.

*π Argus*.—This is a wide telescopic double-star, forming, with a very distant companion of about the fifth magnitude, another double, easily visible as such with the naked eye. The color of the large third-magnitude star is a strongly-marked orange; the other two are indigo-blue. It is a well-known fact, that a large yellow or orange-colored star has frequently a distant companion of a blue or green color. It is generally supposed that this is a sort of *primâ facie* evidence that the two stars are in some way physically connected. It seems to me that the existence of these complementary colors in apparently neighboring stars in no way indicates *per se* that they are physically connected. I am inclined to think that, given a large bright orange star, with a smaller star naturally very white and nearly in the line of sight, this latter must appear greenish or bluish. The light of the bright orange star fatigues the eye as far as its power of receiving the impressions which we call red, orange, and yellow is concerned. Now, when the eye is directed to the smaller star, the less refrangible portion of the light coming from this fainter object is unable to act with its normal effect, while the green, the blue, and the violet rays, by which the eye has not been fatigued at all, produce their ordinary impression.

It is commonly said that this explanation may be true enough in a few cases; but that, if the bright star is hidden behind a thick bar placed across the field of the telescope, and the smaller star still appears blue or green, it is a proof that the light of the smaller star is really blue or green, and that its color cannot be the effect of mere contrast. This is, I feel sure, fallacious. I have often tried the experiment and at first it was very disappointing, for one would naturally expect that a star, which appeared colored in the presence of a very bright companion, would show its color still more distinctly when that companion was hidden from view. But this never happened, the more completely the light of the larger star was removed, the less was color in the companion observable. I feel persuaded that, if the light of the larger star could be entirely cut off, which, by-the-by, is impossible, the blue color would entirely disappear. It is worth noting, too, that the longer one looks at a blue star, its companion being hidden, the more completely does the blue color disappear; that is, I take it, as the eye recovers its normal condition, after being exposed to a severe strain from the light of the large star, so does its sensitiveness to the feeble red, orange, and yellow rays of the small star return, and it sees the small star to be white or nearly so. On the other hand, I have often noticed that the longer one looks at a double star of this kind, both stars being in the field, the more pronounced does the blue become. There is only one instance, that I am aware of,

in which this theory will not hold good. The small companion of *a Scorpii* is undoubtedly really greenish. I saw it on the 23rd of March, 1878, emerge from behind the moon after an occultation while its bright companion was still hidden, its color then was a pale pea-green. There could have been no contrast here, except with the moon's light; admitting this exception, however, it seems to me highly probable that while, in such wide double stars as  $\pi$  *Argus* and  $\gamma$  *Crucis* the orange or yellow star is really what it seems, the star that appears green or blue is, *as a rule*, really white. If this view is the correct one, it follows that those observers who spend a great deal of time in observing the tints of the companions to large stars, are, to a great extent, wasting their time.

$\gamma$  *Argus*.—This fine second-magnitude multiple-star has a very curious spectrum. It belongs to a very small class of stars, the only other one that I have heard of is in the Northern constellation *Cassiopeia*. In the spectrum of  $\gamma$  *Argus* there are certainly three very *bright* lines, one rather faint, and, I believe, many finer ones. I am almost certain, too, that there are several fine dark lines in the spectrum. The brightest line is, not improbably, the F hydrogen line; and the somewhat fainter one, the C hydrogen line. Of the other two very distinct bright lines, one is certainly not very far from the position of the D sodium line; but I cannot place the other. The presence of bright lines in the spectrum renders it far more difficult than usual to estimate the positions, but the other line seems to be about one-third of the distance from D towards the iron line E. Not improbably then, outside the photosphere of  $\gamma$  *Argus*, there are ever-present enormous masses of hydrogen and sodium, as well as other substances in the gaseous condition, which have been ejected from the more central parts of this sun; and, the temperature of these incandescent gases being much higher than that of the solar photosphere below, their spectrum is super-imposed on the ordinary spectrum of the star proper.

$\epsilon$  *Argus*.—This yellow star belongs to Secchi's second class. In these stars the lines are very fine, and not easily seen unless the weather is very favorable. To this class our sun belongs. In the spectrum of  $\epsilon$  *Argus* the F line can be seen pretty easily, but the D sodium line seems to be the most distinct of this spectrum.

$\beta$  *Argus*.—Magnitude, one and a-half. Color, white. A first-class star. The hydrogen lines are pretty broad and distinct.

The blue Planetary Nebula near the Southern Cross.—This object, No. 3365 in Sir John Herschel's Catalogue, is in R. A. 11hrs. 44m., and decl.  $56^{\circ} 31' S$ . The color of this strange object is a bright unmistakable blue. This nebula, like other planetary nebulae that have been examined in the Northern Hemisphere, gives a spectrum of one bright line. Possibly, in a larger instrument, more lines might be seen. It is, of course, impossible with my apparatus to determine the position of this line, as there are no landmarks, so to speak, to guide one to a decision. It is most probable, however, that it is one of the hydrogen or of the nitrogen lines, and that this planetary nebula is a spherical mass of one or both these gases in an incandescent state.

$\alpha$  *Crucis*.—This superb *pair* of stars, by far the finest in the sky, consists of two stars, bluish white in tint, and very nearly equal in size, each being of the second magnitude. There is a distant six-magnitude companion, of a sea-green color, as well as three smaller comites of magnitudes, 12½, 14, and 13 respectively. These latter are well seen in the 8½-inch reflector, but a small telescope of course does not show them. I have made a very great number of measures of the angle of position of this star, and having weighted the observations with reference to the state of the atmosphere, etc., at the time when the measures were taken, I find the angle of position for the year 1878.7 to be  $118.5^{\circ}$ . This by a very singular coincidence, is exactly the same angle as that obtained by

Powell in the year 1863. Herschel gives the angle for 1835.33 as  $120.6^{\circ}$ . I may say that, if I had rejected two of my observations, which were made in rather bad weather, and which exceeded the average of the rest by  $1\frac{1}{2}^{\circ}$  and  $3\frac{1}{2}^{\circ}$  respectively, the angle obtained, taken in connection with Powell's and Sir John Herschel's, would have indicated, I believe, a very slow but really regular angular motion, in a retrograde direction, since Herschel's time, and would, with the measures of distance given below, have convinced me, at all events, that  $\alpha$  *Crucis* is a binary star of very long period. The temptation in such cases to "cook one's accounts" a little to omit taking into account facts or numbers which do not square with one's own views or wishes, is very strong, but the man who cannot resist it had better give up science altogether and take to something else in which it is not of vital importance that he should tell the truth, the whole truth, and nothing but the truth, with regard to his observations. The distance between the two stars at the epoch, 1836.36, was  $5.65''$ ; in 1863, Powell made it  $4.98''$ ; and at the end of last month, 1879.75, the distance, a mean of several measures, was  $4.79''$ .  $\alpha$  *Crucis* is a hydrogen star, but its spectrum is very difficult to observe, except in the finest weather. Even then the only lines that I can make out are the hydrogen lines, and they are by no means very easy to see.

$\gamma$  *Crucis*.—It has been customary for astronomers to catalogue this star—the "Head of the Cross"—as a double star; but the proper motion of the large orange-colored star is rapidly carrying it away from its five-and-half-magnitude blue companion. The spectrum of  $\gamma$  *Crucis* is perhaps the finest of all stellar spectra. The groups of lines are so numerous and so well marked that this spectrum may be observed under almost any atmospheric conditions, if the star can be seen at all.  $\gamma$  *Crucis* is a typical star of Secchi's third class, which are all orange color verging towards red. In their spectra there are numerous, easily-seen, close groups of lines; but the hydrogen lines are either very indistinct or altogether absent.  $\alpha$  *Orionis* and  $\alpha$  *Herculis* are good specimens of the two principal subdivisions of this class. In the spectrum of  $\gamma$  *Crucis* there are at least eight broad groups of lines, and some of these occupy the parts of the spectrum at which sodium, iron, magnesium, and calcium lines are found in the solar spectrum. But, because they are groups, it is much more difficult to say whether they contain the lines belonging to those elements or not, than it is in the case of a first or second-class spectrum. Still, I anticipate that careful measurements will confirm my opinion that iron and magnesium lines, especially the latter, are present in the spectrum of this star; the sodium line is probably there too. There is, also, a fine line just at the part where the green merges into the blue of the spectrum. This is possibly the F hydrogen line.

There is one very significant feature in this spectrum, so at least it seems to me. It is well known that when the Sun is near the horizon, especially in damp weather, his spectrum contains certain groups of lines which are due to the aqueous vapor in our own atmosphere, and that, as he reaches a greater altitude, these lines become faint or disappear. Now, two at least of the groups in the spectrum of  $\gamma$  *Crucis* appear to occupy the same position as two of the principal groups of atmospheric lines. Now this being verified, important conclusions might follow. Secchi, on grounds of this sort, infers the existence of aqueous vapors in the neighborhood of sun-spots. The Spectroscope knows nothing, so to speak, about distance, except indeed where motion of approach or recession is concerned. If these aqueous vapor-lines are produced in spots on the sun, may they not be produced in much the same way in  $\gamma$  *Crucis*, the principal difference being that on the distant star the cause is more general and the effect greater than it is on our own Sun. If I am not mistaken, the existence of these spectrum lines should enable us to read a certain portion of the "life history" of a star.

This history might be something like this: Let us suppose that, countless ages ago,  $\gamma$  *Crucis* was a white star, like *Sirius*. It was then far more intensely heated than it is now. All the elements of which it is composed were there uncombined. Hydrogen, the gas of the smallest density, ordinarily extended furthest from the centre of the globe, and this hydrogen, its outer envelope, was nearly always near the confines of the normally cold regions of space. Thus it would have a somewhat lower temperature than the rest of the sphere, and hence well-marked hydrogen lines would appear in its spectrum at this period. Comparatively small quantities of other elements, however, would frequently be erupted from the interior portions of the sphere, and would reach what may be called the surface. The presence of these would cause the appearance of numerous fine lines in the spectrum. As eternity went on, if I may use the expression, the star radiated a large portion of its heat into space, the elements began to combine chemically to a certain extent, large volumes of hydrogen ceased to exist as such, through combining with oxygen and forming water-vapor, of which the outer star envelope would now consist. In place of the hydrogen lines of the white star therefore, we now find the aqueous vapor spectrum—"the atmospheric lines" as they are called. The result of the combination of the oxygen and the hydrogen would, of course, be a great decrease in the volume of the outer envelope. This would probably bring the lines of sodium, magnesium, iron, and calcium into greater prominence, and we should have the spectrum which  $\gamma$  *Crucis* now presents. Between the two conditions described there would be an intermediate one. Through such a stage our Sun may possibly be passing now. It may be, in short, that our Sun was once a *Sirius*, is now a *Procyon*, and will by-and-by be a  $\gamma$  *Crucis*. This is a mere hypothesis, of course, though it appears to account pretty fairly for some of the phenomena of the stars. In fact, I give it merely as a suggestion, feeling that it is as little entitled to carry weight with it as an hypothesis, founded on observed phenomena and not at variance with known facts, can be.

$\gamma$  *Centauri*.—R. A. 12hrs. 34min. 21.46secs. Decl.  $58^{\circ} 14' 43.24''$ .—This is a very fine close pair of stars, each component being of the fourth magnitude, and purely white. In his "Results of Observations at the Cape of Good Hope," Sir John Herschel gives the position-angle as  $354.3^{\circ}$ , the epoch being 1835.89, while the distance is stated to be  $\frac{3}{4}''$ . To this estimate of distance Herschel attaches no value. For the year 1878.93 the angle of position is  $6.6^{\circ}$ , or  $186.6^{\circ}$ , and the distance  $2.2''$ .

$\beta$  *Crucis*.—This fine white star has a distinct deep blood-red companion, the position angle being  $260\frac{1}{2}^{\circ}$  and the distance (1879)— $208''$ . It seems to me that the small star varies in size from about the eleventh to nearly the eighth magnitude. It would be well if the small star could be watched, so that its period and the amount of its variation in brightness might be accurately ascertained.

$\alpha$  *Centauri*.—R. A. 14hrs. 30min. 47.07secs. Decl.  $60^{\circ} 17' 53.93''$ . Magnitudes, 1-2. The following table will give the position-angles, and the distances of the components of this star, for selected epochs during the forty-five years which have elapsed since 1834, when it was first accurately measured by the greatest of all astronomers, Sir J. Herschel:

| OBSERVER.                                | Date.   | Position.         | Distance. |
|------------------------------------------|---------|-------------------|-----------|
| Sir J. Herschel.....                     | 1834.7  | —                 | $17.43''$ |
| Sir J. Herschel.....                     | 1834.8  | $218^{\circ} 30'$ | —         |
| Sir J. Herschel.....                     | 1835.7  | $219^{\circ} 30'$ | —         |
| Sir J. Herschel.....                     | 1837.3  | $220^{\circ} 42'$ | —         |
| Sir J. Herschel.....                     | 1837.4  | —                 | $16.12''$ |
| Pewell (from Webb).....                  | 1864    | $5^{\circ} 7'$    | $7.85''$  |
| Computed from mean places in F. M. G. C. | 1870.0  | $17^{\circ} 19'$  | $10.73''$ |
| My recent measures.....                  | 1878.7  | $156^{\circ} 19'$ | —         |
| My recent measures.....                  | 1879.75 | $183^{\circ} 8'$  | $4.55''$  |

With this table as a basis, it will be found that the major axis of the apparent orbit lies nearly in the direction  $26\frac{1}{2}^{\circ}$  to  $206\frac{1}{2}^{\circ}$ , and that the greatest elongation north is about  $11''$ , while the greatest elongation south is  $27''$ . Mr. Powell makes the period between 76 and 77 years. If the places of the two stars given by Lacaille (1750) were correct, however, the period would be just about 85 years, for the angle of position computed from his places of the stars is  $218^{\circ} 44'$ , which a reference to the above table will show, was very nearly Sir John Herschel's micrometrically-determined position 84.79 years afterward. As, however, the distance obtained by Sir John Herschel disagrees very materially with that deduced from Lacaille's places of the stars, but little weight is attached to the observation of 1750.

This magnificent double star is the finest object of the kind in the heavens. Besides being a binary star of very short period, every one knows that  $\alpha$  *Centauri* is our next neighbor among the stars, and that it was the first to give up the secret of its parallax under direct Transit Circle observations. The color of this star is straw-yellow, or sometimes golden-yellow, according to the state of the atmosphere. When there is haze, of course the smaller star is somewhat more affected by it than the larger. This tends to give it a slight brownish tint when the sky is not clear.  $\alpha$  *Centauri* is a star of the second class. Its spectrum is very like that of the sun. Even the principal dark lines are fine, and they apparently occupy the same relative positions as do the well-known lettered lines in the solar spectrum.

The resemblance between the two spectra is so striking that any one seeing the two spectra for the first time could hardly fail to notice the similarity. More dispersive power, however, and the means of accurately determining the position of the lines of  $\alpha$  *Centauri* might show that they are not the same as the solar lines. Such a result would surprise me much. The D sodium line, the E iron line, the  $b$  magnesium line, and the F hydrogen line of the Sun have, almost certainly, their counterparts in the spectrum of  $\alpha$  *Centauri*. There can be little doubt that the physical constitution of this great star is, in most respects, the same as that of the Sun. It is probable, however, that  $\alpha$  *Centauri* is less developed than the Sun; for, as Mr. Proctor has pointed out, its light is brighter than its mass would lead us to expect it to be, judging from the light of our Sun, as compared with his mass. While the mass of the star is to the mass of the Sun as 2:1, the light of the star is to the light of the Sun as 3:1. Now, if it is true, as physicists have good grounds for believing, that the Sun is, and has been, very slowly but surely losing his heat, just as our earth has most certainly lost an enormous amount of hers, there must have been a time when the Sun and his system were less developed, but far hotter and brighter than they are now—when they formed, probably, as I said when speaking of  $\gamma$  *Crucis*, a white star—that is to say, there was, quite possibly, a time when the light from our Sun bore the same relation to his mass as the light from  $\alpha$  *Centauri* bears to its mass. We may also believe that matters are less advanced in the planets (if there are any) of this neighboring system than they are with us.

$\alpha$  *Trianguli*.—The spectrum of this star is not very striking, but it is rather curious, as showing, apparently that the star is in a condition intermediate between that of  $\alpha$  *Centauri* and that of  $\gamma$  *Crucis*. The lines of the second class, and also the groups, are very faint, but they are there. It will be seen that this fact has some bearing on the suggestion I made respecting the gradual development of stars while speaking of  $\gamma$  *Crucis*. Here it looks as if we had, so to speak, caught a star in the act of changing from the second to the third class. What I have seen of the spectra of the stars, so far, leads me to think it probable that if every star, down to the sixth magnitude, could be examined even with my instrument, and mapped roughly, it would be found that the spectra

obtained could be so classified that a series might be made, each member of which would differ from the next almost insensibly. This, of course, would take a long time to do, as small stars can be examined only in very fine weather. When it was done, however, the results would be very valuable and interesting.

*a Gruis*.—This is a second-magnitude white star, with the usual spectrum crossed by distinct hydrogen lines.

$\beta$  *Gruis* is a second-magnitude star, and nearly as bright as the *lucida* of this constellation. Its color is reddish-orange, and its spectrum is much like that of  $\gamma$  *Crucis*, but the groups of lines are not so distinct, and, generally, there is a sort of approach to the appearance presented by the spectrum of *Mira Ceti*, which I find thus described in my note-book, under the date October 8th, 1878: "Saw to-night the spectrum of *Mira*: it is really wonderful—something like that of *a Herculis*, as given by Chambers. It seems to consist of bright broad bands, with narrow ones in between. These bands are dark, but hardly black. The effect produced is, as it were, that of an irregular set of columns. The brightest part of the spectrum is at the yellow and the green."

*a Piscis Australis (Fomalhaut)*.—This star is visible at home sometimes, but its altitude there is so small that it can scarcely be properly observed with the spectro-scope. *Fomalhaut* is a first-class star of the most pronounced type; it is very remarkable for the great breadth of the F hydrogen line. In *Fomalhaut* it is far broader than it is even in *Sirius*. As an increase in the breadth of the hydrogen lines has been shown to be due to increased pressure, and as the increase in breadth is also proportional to the pressure brought to bear upon the gas which gives the lines in the spectrum, we may, I would venture to suggest, conclude that the pressure at the surface of this star is extremely great. That is to say, *Fomalhaut* is either extremely dense and compact, so that its radius is very small compared with its mass (which is not very likely), or it is one of the very largest stars in the sky.

In conclusion, I would ask you to overlook any faults of style that may be observable in this paper. It claims to be nothing more than its title announces it to be—"Notes on Southern Stars."

#### SCIENTIFIC BOOKS.

Mr. W. H. Farrington recently gave an interesting Lectures on scientific books before the American Institute, a full report of which may be found in *Engineering News* of March the 19th. He said that in spite of the large number of scientific works published, there still are constant enquiries for books on certain subjects, which have yet to be written. This he explained was due to various causes, one being that the demand for certain books do not warrant their publication, and secondly, that many works treating on manufactures are withheld, it being the policy of those who could write them, to keep from the public such information. He stated that the English publishers seldom stereotype their better class of books, but print from the type, whereas in America it is the custom to print from such plates, permitting a much smaller edition to be issued. Those interested in the literature of Mechanics, and "*Engineering Science*," should read Mr. Farrington's Lecture from which they may gather many practical hints respecting the purchase of such books.

#### ASTRONOMY.

THE March number of the *American Journal of Science* contains a paper by T. C. Mendenhall, of Tokio, Japan, "On the Determination of the Coefficient of Expansion of a Diffraction Grating by Means of the Spec-

trum." The object of the research was to find the coefficient of expansion of the peculiar alloy of tin and copper, now generally used for ruling gratings. The value of the coefficient of expansion is independent of the wave-length of the line upon which the measurements are made and of the number of lines to the inch. The temperature of the grating was altered by placing the plate in one end of a small wooden box which could be filled with water and brought to any given temperature. The resultant value for the coefficient of expansion from the mean of twenty measurements is

$$E = .0000202$$

DR. MEYER, Assistant Astronomer at the Geneva Observatory, has employed the microphone in transmitting the beats of the standard clock of the Observatory to different parts of the building, and also to the Regulating Clock of the city Time Service. The microphone is fixed upon the outside of the clock-case and placed in circuit with a small battery and a telephone. The beats of the clock can then be readily heard throughout the room.

AT the request of the Treasury of the Royal Astronomical Society, a committee has been appointed to advise the Government upon the steps which it is desirable to take in order to secure observations of the Transit of *Venus* across the sun's disk, 1882, December 6. The committee—which consists of the Astronomer Royal, the President of the Royal Astronomical Society, the President of the Royal Society, Professor J. C. Adams, the Earl of Crawford and Balcarres, Dr. De La Rue, Dr. Huggins, Professor H. J. S. Smith, Professor Stokes and Mr. Stone—has already commenced its labors.

ABOUT a year ago Admiral Moucher asked for a credit of 4,000 francs per year in order to publish a monthly astronomical review. M. Jules Ferry refused the grant, but a similar review is now being published at Brussels under the name *Ciel et Terre*. It appears twice a month and is devoted to meteorology and astronomy.

THE second number of *Urania* contains quite an elaborate article by H. C. F. C. Schjellerup, entitled, "Recherches sur L'Astronomie des Anciens;" also a short communication upon Observations of the Spectrum of Comet 1880 f. (Pechüle) at Dun Echt, and a "Circular from the Smithsonian Institution."

A NEW VARIABLE STAR.—M. N. C. Dunér, of the Lund Observatory, reports upon the 24th of February, 1881, the discovery of a new, small variable. The star is given in the Bonn Durchmusterung (1855.0)

$$9.4 \text{ mag. } R. A. = 5^h 17^m 32^s.7.$$

$$\text{Dec.} = + 34^\circ 2'.1.$$

THE asteroid, No. 217, discovered by Coggia at Marseilles on the 30th of August, 1880, has recently been named "*Eudora*."

WASHINGTON, MARCH, 1881.

W. C. W.

We are informed by Professor Davidson that the following is the correct geographical position of the Davidson Astronomical Observatory, San Francisco, Cal.:

$$\text{Latitude} = 37^\circ 47' - 22''.3 \text{ North.}$$

$$\text{Longitude} = 122^\circ 24' - 39''.0 \text{ West of Greenwich.}$$

$$\text{In time} = 8^h 09^m 38^s.6$$

This differs from the figures we recently gave at page 107, in the number of seconds in time.

## BOOKS RECEIVED.

THE TELESCOPE. By THOMAS NOLAN, B. S. D. Van Nostrand, 23 Murray Street. New York, 1881. Price 50 cents.

This little handbook presents very briefly the principles involved in the construction of refracting and reflecting telescopes, illustrated with about thirty diagrams. For an amateur desirous of following Herschel's example of making his own telescope, this work will be found a practical guide. We notice the author gives the form of object glass suggested by Messrs. Alvan Clark & Sons, the noted makers of astronomical object glasses. They say "many forms may be used, but from our experience, we have found that to make the crown glass lens of equal curvature, and the flint glass lens nearly flat on the side next the eye, is the most convenient, and gives as good results as any other form."

## MICROSCOPES.

The *American Journal of Microscopy* for March is an excellent number full of interesting matter and two full pages of illustrations.

We notice Professor Phinn corrects a statement mentioned in *Journal of R. M. S.* that 80,000 to 100,000 diameters were within the power of his appliances. He now gives as the limit of amplification of a high angle objection, say, an object of one tenth, and a one eighth eye-piece, 8,000 to 10,000 diameters. We notice in another part of the *Journal* that Professor J. Edwards Smith obtains 8,000 with the same-eye piece and a  $\frac{1}{8}$  object.

Dr. E. Cutler describes a flagellate infusorium called *Asthmatos Ciliaris*, which occurs in connection with one form of contagious cold coryza or influenza. These parasites may be easily detected in the early sneezing stage, the nose runs and the eyes water; they are located in the anterior nasal passages, on the mucus membrane of the conjunctiva of the eyes, and of the pharynx and larynx. Simply transfer a drop of the thin mucus to a slide, cover, then examine with a good 1-5th and 1 inch ocular.

There appears to be confusion as to the classification of this parasite, and as the opportunity for studying it will probably be oftener than agreeable, we shall be glad to hear from any of our readers who throw light on the subject.

Dr. F. L. Bardeen considers that wax cells have been too hastily abandoned by their originator, Professor H. L. Smith, who fully described them in "SCIENCE." Dr. Bardeen says that if prepared as he suggests, they are the best cells for opaque mounting.

Dr. A. C. Stokes has an excellent paper on "Growing Slides," and treats the subject in a most exhaustive manner; as most of the contrivances can be made by the microscopist, this article will be of the greatest benefit to this class.

Dr. Smith Baker, in a paper on the "Microscopical uses of the Cat," offers a plea for the more universal use of this domestic animal in microscopical study.

In view of the advice offered by Professor Burt G. Wilder, in regard to the use of the cat by anatomists, and the increasing disposition of students to use the cat for such purposes, we fear that this genus will soon be at a premium.

MANURIAL EXPERIMENT WITH SUGAR BEETS.—Phosphoric acid, applied preferably in the spring, increased the yield of sugar most decidedly.—M. MARCKER.

OCCURRENCE OF VANILLA IN RAW SUGARS.—The authors have succeeded in isolating small quantities of vanilline from crude-sugar.—E. v. LIPPMAN and Prof. C. SCHEIBLER.

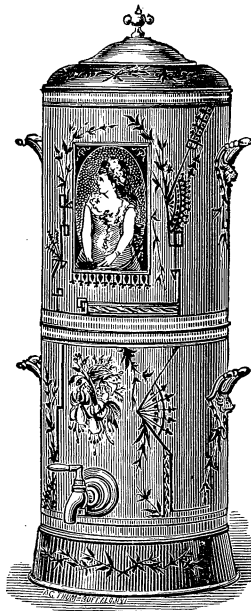
## THE GLYCERINE BAROMETER.

Mr. James B. Gordon has published the following description of his glycerine barometer—which appears to have at least one advantage in being easily read off, as the usual tenth of an inch on the mercurial barometer is represented in the glycerine barometer by something more than an inch; thus the changes which take place are rendered obvious even to an unpracticed eye.

Our readers may have heard of Daniell's water barometer, which was destroyed in the fire at the Crystal Palace in 1866. Mr. Jordan constructed another, which has since continued in operation. In the course of his experiments on various fluids, he was led to try glycerine, which appears well adapted for the purpose. Its vapor has a very low tension at ordinary temperatures, and as its freezing-point is much below zero, it is, so far, excellently adapted for use in barometers. The mean coefficient of expansion by heat is, according to Professor Reinold, .000303 for a degree of Fahrenheit's scale, and a table has been computed on this basis for reducing the observations to 32° Fahr. Glycerine possessing the capability of absorbing moisture from the atmosphere, its surface in the cistern is covered by a layer of mineral oil, which has no effect whatever on the glycerine, and which does not evaporate at ordinary temperatures. At sea-level the pressure of the atmosphere supports a column of glycerine of a mean height of 27 ft., and accordingly the tube of the barometer is made some 29 ft. in length. It is formed of composition gas-pipe,  $\frac{5}{8}$ ths of an inch in diameter, but the upper part, 4 ft. or so in length, is of glass tube, having an internal diameter of  $\frac{1}{8}$  in. The top end, instead of being sealed, is spread out into a cup-shape, having a small orifice plugged with a stopper of rubber. The cistern is of tinned copper  $\frac{1}{4}$  in. deep and  $\frac{1}{2}$  in. in diameter, and the air is allowed to press on the surface through a small hole leading into a chamber containing a filter of cotton wool. At the bottom of the cistern is a closed channel opening into the centre, and to this is attached a projecting vertical tube, to which the main tube is soldered. The object of this channel is apparently to provide a means of closing the tube by a screw-plug when refilling is necessary. The quantity of glycerine required for such an instrument is about a gallon, and this being warmed in a water-bath and tinted with rosaniline, sufficient is poured into the cistern to cover the orifice of the channel. The plug at the top end is then removed, and the tube completely filled by pouring the glycerine gently down one side. After allowing it to rest for some time, the air bubbles will be found collected at the top, when the tube is again filled up to the cup, and the stopper replaced. The screw-plug in the cistern being removed, the column will fall until balanced by the pressure of the atmosphere, and the vacuum is as perfect as it is possible to get it, the small quantity of glycerine remaining in the cup above the stopper hermetically sealing it. The glycerine barometer is therefore a simple and easily managed instrument; but it is not pretended that it can take the place of the standard mercurial instrument for precision. It is comparatively a new instrument, and its value as a piece of scientific apparatus has yet to be shown.

HYDROBROMIC ACID AS A REAGENT FOR COPPER.—A drop of the solution in question is placed in a watch-glass, a drop of hydrobromic acid is added and the mixture evaporated at a gentle heat. When it is reduced to the bulk of one drop a rose-red coloration appears, three or four times more intense than that produced by potassium ferrocyanide. In this manner 1-100th milligram copper may be detected.

DETECTION OF METHYLIC ALCOHOL IN VINIC ALCOHOL.—MM. Cazeneuve and Cotton propose as reagent a solution of potassium permanganate containing 1-10th per cent of the dry salt. The permanganate at ordinary temperatures is reduced slowly by vinic alcohol, but instantaneously by methylic alcohol. If to 10 c.c. of alcohol at 20° there is added 1 c.c. of the permanganate solution, twenty minutes are required before the liquid takes the yellow tint indicating complete reduction. If 10 c.c. of alcohol are used containing 1 c.c. of methylic alcohol the yellow tint is instantly obtained with potassium permanganate.



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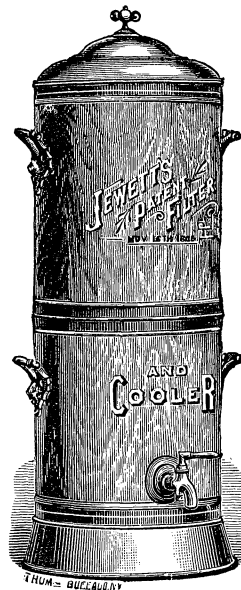
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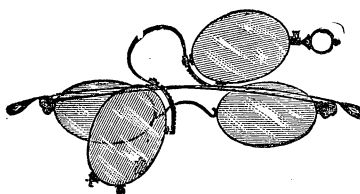
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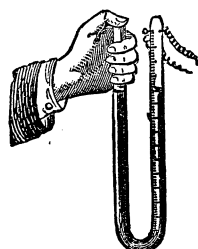
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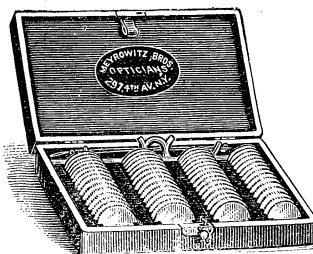


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